LANDWISE NFM

TRADE-OFF BETWEEN FARM PRODUCTION AND FLOOD ALLEVIATION USING TILLAGE AS NATURAL FLOOD MANAGEMENT (NFM) STRATEGY.

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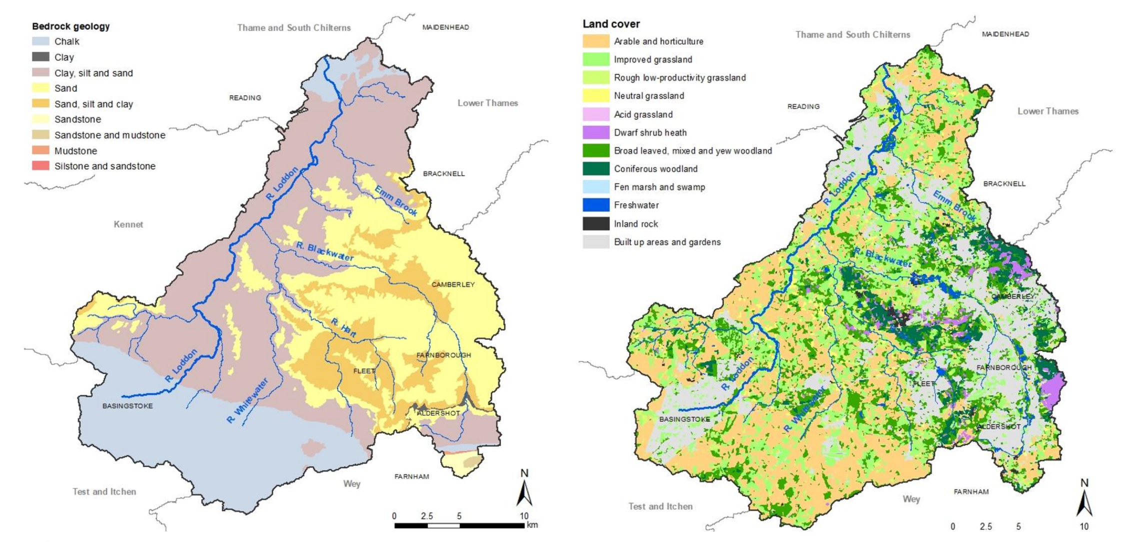
Introduction

Primarily, tillage practices are realized for management of crop production. They also serve as natural flood management (NFM) strategy to create soil surface roughness, improving water absorption, infiltration, and storage in soil profile. But mechanical working damages soil structure and causes compaction, erosion, and soil organic carbon loss which aggravate flooding risks during rainfalls. Importantly, adverse above phenomena develop over time with fewer awareness of causalities and evidences in changing climate. Hence, inspiring towards heavy tillage could aggravate flooding risk compromising crop production futuristically. We conducted this study to highlight tillage as NFM strategy towards sustainable resolution.

Objectives

Followings are the main objectives of this study anchoring tillage as NFM strategy :-

- ❖ To identify interacting (causal) variables towards flood alleviation and farm production.
- ❖ To develop a meta-model *e.g.*, Bayesian Belief Network (BBN) for tillage as NFM.
- ❖ To quantify variables in the BBN model exhibiting their strength and sensitivity.
- ❖ To measure trade-off relationship between flood alleviation and farm production using tillage as NFM strategy.



[1]**Figure 1:** Maps of bedrock geology and land cover data of Loddon catchment.

Methodology

A BBN model for tillage is developed with causal variables to eminence their impacts on flood alleviation and farm production to quantify their influence based on their potential strength of interactions. This can help decide practitioners for their informed choices.

i- Exploring interacting (causal) variables

We developed a novel approach called ***"Scientific Published Literature (PSL)"*** to identify interactive (causal) variables in a multi-domain studies and successfully applied.

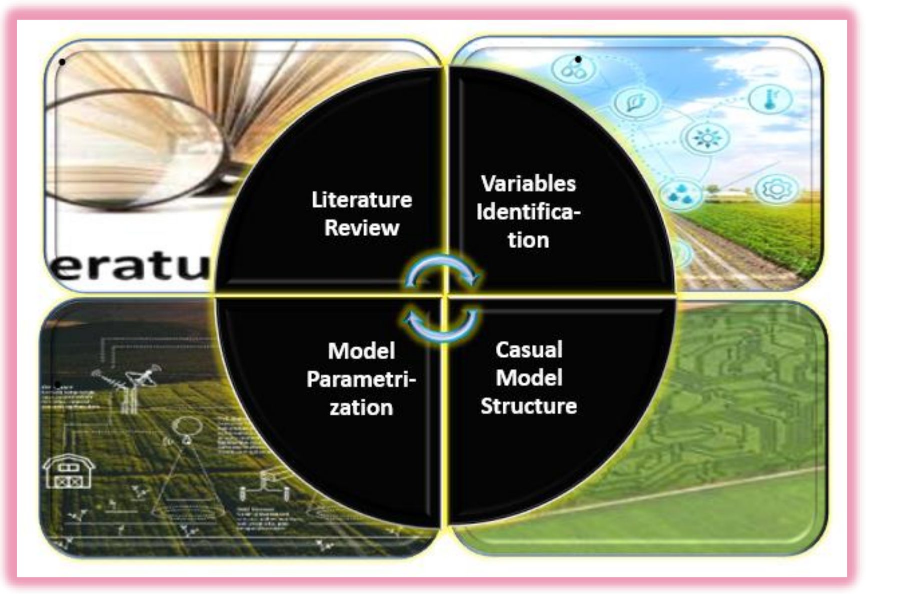


Figure 2: "Published Scientific Literature (PSL) approach is shown as a cyclic process involving literature review to identify variables from eco-agri-environment domains and then connecting them based on their causal relationships into a BBN model structure making it ready for parametrization and constantly improving that over time."

Twelve (12) Variables identified using Published Scientific Literature (PSL) approach			
Soil Texture	Tillage practices	Weeds Emergence	SOM/ SOC
Infiltration	Soil Compaction/H. Bulk Density	Erosion	Surface Runoff
Drainage	Nutrients Loss	Effect on flood alleviation	Effect on farm yield

Seventeen (17) relationships identified using Published Scientific Literature (PSL) approach	
Soil texture type to tillage	Weeds to nutrients loss
Tillage practices to weeds	Erosion to nutrients loss
Tillage to erosion	Runoff to nutrients loss
Tillage to compaction	Runoff to erosion
Tillage to SOM/ SOC	Runoff to drainage
SOM/ SOC to infiltration	Nutrients loss farm yield
Compaction to runoff	Drainage to flood alleviation
Infiltration to runoff	

ii- Elicitation of experts' knowledge

Semi-structured interviews were conducted from six (6) domain experts and developed individual Bayesian network structure.

Expert	Expertise/ Specialization	Variables Identified	Interactions Identified
1	***Hydrologist*** with specilisation for water pollution at ecosystem, catchment and continental scale.	15	28
2	***Environmental & social scientist*** for land uses, communities and policies involving local decision making.	15	31
3	***Environmental scientist*** for carbon and water cycles in ecosystems domains from test tube to catchment scale.	14	26
4	***Crop scientist*** for plant physiology, biology, and genetics research in biodiversity, crops, and agro-econsystems.	14	27
5	***Soil scientist*** with specialisation for soil biochemistry in agricultrual, natural, and polluted environements.	14	25
6	***Practicing farmer*** managing a farmhouse practicing mix farming of raising livestocks, and arable crops.	18	49
Source	**Study Domains**	**Variables Identified**	**Interactions Identified**
***PSL** Method	Agriculture, Ecology, Agri-Environment, Climate Change.	12	17

***PSL** = "Published Scientific Literature"

iii- Constructing BBN structure

Below variables were commonly identified by all six domain experts as well as through PSL.

Variables commonly identified using PSL approach & knowledge elicitation from individual experts.	
Tillage practices Soil texture type *Soil cover/ Weeds cover *Soil organic matter/ Soil organic carbon *Soil compaction/ Bulk density Erosion Surface runoff *Nutrients (loss/ competition/ leaching/ access) Effect on flood alleviation Effect on farm yield	Expert 1 Expert 2 Expert 3 Expert 4 Expert 5 Expert 6

*Some of the variables with related phenomena were grouped together for interchangeable uses.

Commonly identified variables by experts and through PSL combined with few most pertinent climatic variables, slope, and farming systems into a DAG using Netica software. [2]Decision Support System for Agrotechnology Transfer (DSSAT) was also used for data simulation.

BBN Model for tillage

A BBN model for tillage shows three sub-models.

Sub-model-I has brown nodes using climatic variables (*e.g.*, rainfall & temperature) and crop (wheat) growth variables with simulated data generated through DSSAT model for its parametrization.

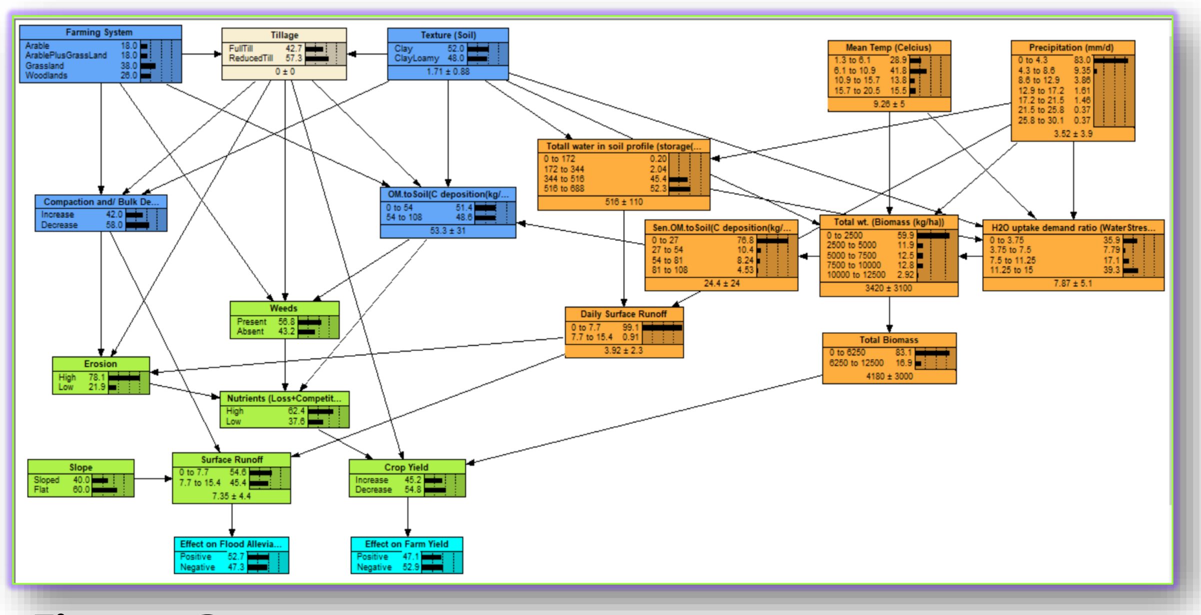


Figure 3: A BBN model for tillage with three sub-models parametrized using synthetic (brown nodes), empirical (blue nodes) and elicited (green nodes) dataset.

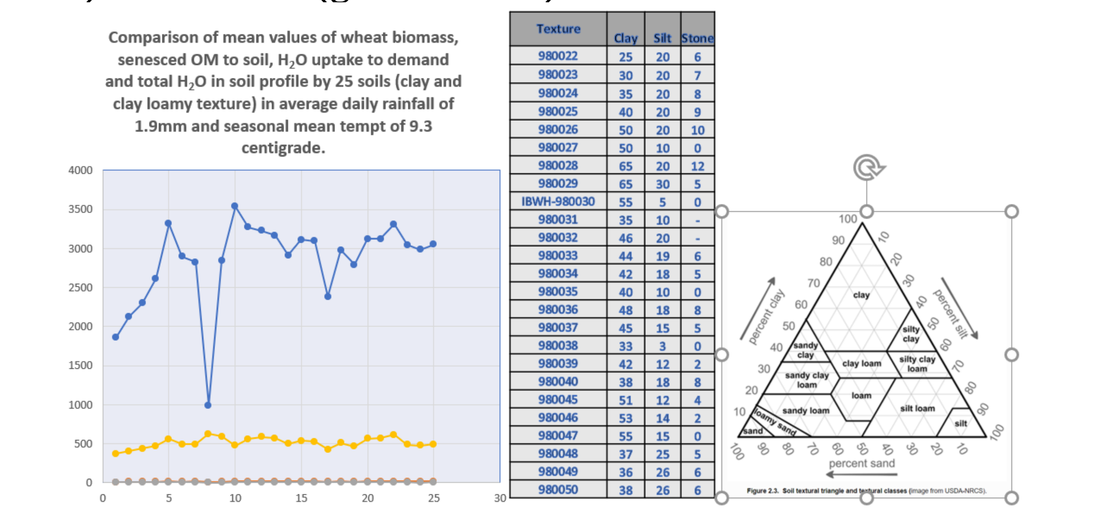


Figure 4: Responses of various variables in sub-model-I of climatic & crop growth variables including range of clay and clayey loamy soils with varying percentage proportions of compositions. (Catchment is predominantly having clay and clay loamy soils.)

Sub-model-II has blue nodes which are parametrized using empirical data extracted from field surveys and experiments explored tillage, farming system, compaction, bulk density and SOM/SOC.

Sub-model-III has green nodes which are representing variables parametrized (defined conditional probability table - CPT) by elicited knowledge of domain expert as limited datasets are available for them.

Conclusions

This BBN depicts the following inferences.

- ➢ Propensity to full tillage practices increases farm yield along with increased soil compaction generating higher runoff and resultantly reduces the effect of flood alleviation but the vice versa if reduced tillage is opted.
- ➢ Tendency to increasing arable & arable with grasslands farming systems also increases the farm yield involving more tillage triggering increased compaction causing higher runoff and resultantly exhibiting reduction in flood alleviation but the vice versa if grasslands or woodlands opted comparatively.
- ➢ There exists a trade-off relationship between flood alleviation and farm yield using tillage as NFM strategy.

References

[1]Source: https://loddonobservatory.org/loddon-catchment/
[2]https://dssat.net/

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